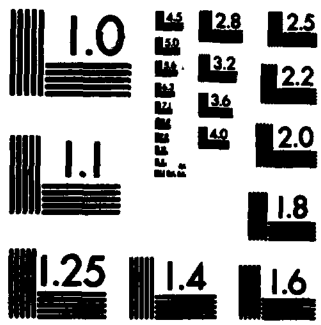
AD-A145 556 RAPIDLY CONVERGENT ALGORITHMS FOR NONSMOOTH OPTIMIZATION(U) WASHINGTON STATE UNIV PULLMAN DEPT OF PURE AND APPLIED MATHEMATICS R MIFFLIN 14 JUL 84 1/1

UNCLASSIFIED AFOSR-TR-84-0727 AFOSR-83-0210 F/G 12/1 NL

END



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

(4)

RAPIDLY CONVERGENT ALGORITHMS FOR NONSMOOTH OPTIMIZATION

INTERIM SCIENTIFIC REPORT, GRANT AFOSR-83-0210

15 JULY 1983 - 14 JULY 1984

14 July 1984

Robert Mifflin
Department of Pure and Applied Mathematics
Washington State University
Pullman WA 99164-2930

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR- 84-0727
6a. NAME OF PERFORMING ORGANIZATION Washington State University 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Air Force Office of Scientific Research
6c. ADDRESS (City, State, and ZIP Code) Dept of Pure & Applied Mathematics Pullman WA 99164-2930	7b. ADDRESS (City, State, and ZIP Code) Directorate of Mathematical & Information Sciences, AFOSR, Bolling AFB DC 20332
8a. NAME OF FUNDING / SPONSORING ORGANIZATION AFOSR 8b. OFFICE SYMBOL (If applicable) NM	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-83-0210
8c. ADDRESS (City, State, and ZIP Code) Bolling AFB DC 20332	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 61102F; PROJECT NO. 2304; TASK NO. A1; WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
RAPIDLY CONVERGENT ALGORITHMS FOR NONSMOOTH OPTIMIZATION

12. PERSONAL AUTHOR(S)
Robert Mifflin

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Interim	FROM 15/7/83 TO 14/7/84	14 JUL 84	3

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Nonsmooth optimization; nondifferentiable programming; constrained minimization; line search.

This research

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The research supported under this grant has led to new developments for solving nonlinear optimization problems involving functions that are not everywhere differentiable and/or are implicitly defined.

For the single variable case a method has been given which combines polyhedral and quadratic approximation, an automatic scale-free penalty technique and a safeguard that insures convergence to a stationary point, but does not detract from rapid convergence. Under relatively weak convergence rate assumptions the algorithm exhibits a new type of better than linear convergence. The safeguard also has the practical advantage of keeping apart points that are used in denominators of difference quotients for approximating second derivatives.

(CONTINUED)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL CPT John P. Thomas, Jr.	22b. TELEPHONE (Include Area Code) (202) 767- 5026 / 22c. OFFICE SYMBOL NM

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

84 08 30 040

ITEM #19, ABSTRACT, CONTINUED: A practical single resource allocation problem with several bounded decision variables has been solved very efficiently via a dual technique that used the single variable method in a nested manner to solve both the outer dual problem and the inner Lagrangian subproblems.

The new concept of better than linear convergence from the single variable case has been generalized to the multivariable case. Author supplied Key words also include: constrained minimization, and line search.

The research conducted under Grant Number AFOSR-83-0210 during the period 15 July 1983 to 14 July 1984 is reported on in [2], [5] and [6].

The goal of this project is to develop methods to solve efficiently constrained minimization problems that have problem functions that are not everywhere differentiable. Such difficult problems occur in practice when decomposition, nested dissection, relaxation, duality and/or exact L_1 penalty techniques are applied to large or complicated nonlinear programming problems in order to convert them to a sequence of smaller or less complex problems. Being able to use these techniques that often give implicitly defined problem functions gives a user flexibility in modeling a problem for solution and the ability to exploit parallel processing in computation.

In [5] the principal investigator developed a reliable and efficient method for solving single-variable optimization problems that may have constraints and may have problem functions that are nonsmooth and/or nonconvex. The method converges to stationary points of problems on which secant and/or cutting plane methods may fail and it converges rapidly on some problems on which these other methods do not exhibit super-linear convergence. The new safeguarding development that insures convergence via a sequence of intervals with decreasing lengths does not detract from better than linear convergence and fits in well with numerical practice, because it keeps apart points whose difference appears in the denominator of a divided difference formula for second derivative approximation. Our new automatic penalty technique for handling a constraint is also numerically sound, because it is independent of constraint scaling and numerically well-conditioned under a mild constraint qualification.

This new single variable method can be used to solve line search problems in multivariable optimization where a line search function value decrease requirement can be imposed via a constraint. Also, it can be used to solve a root (or zero) finding problem on an interval by minimizing the absolute value of the appropriate function subject to a constraint defining the interval.

To show the efficacy of our single variable method and corresponding FORTRAN code we solved a practical single resource allocation problem [1] with five bounded decision variables via a dual or min-max technique. This application used our subroutine in a nested manner, i.e. a single variable "outer" problem was solved where each function evaluation involved solving a five variable "inner" Lagrangian problem that separated into five independent single variable problems. This nested application of our algorithm used somethat less function evaluations that the number used by Powell's sequential quadratic programming code VMCWD [7] applied to the primal problem. If one has the facility for parallel processing then our approach can be made even more efficient by solving the five independent subproblems in parallel. We reported these results at the SIAM Conference on Numerical Optimization held at Boulder, CO in June 1984. We have been invited to write a code description and user's guide for our FORTRAN implementation for presentation at the NATO Advanced Study Institute on Computational Mathematical Programming to be held at Bad Windsheim, West Germany in July 1984. After completing this we intend to revise and improve our earlier paper on a BASIC implementation [2] so that challenging problems can be solved on micro- as well as on more sophisticated computers.

The principal investigator and his Ph.D. student Nilama Gupta are making progress on generalizing the above research to the multivariable case. Part of this work for the unconstrained case was presented at the 11th IFIP Conference on System Modelling and Optimization held at Copenhagen, Denmark in July 1983, and will appear in [6]. This research involves developing a safeguarded piecewise quadratic approximation technique that approximates higher than first order information and leads to a new concept of better than linear convergence. This method is being designed to converge to stationary points of problems with semismooth functions (a concept developed under Grant Number AFOSR-74-2695 [3]). It should converge rapidly under stronger assumptions including an underlying piecewise C^2 structure.

The proposed method requires the solution of a certain indefinite quadratic programming subproblem, so our Ph.D. student Amal Al-Saket is developing a numerically reliable method to solve such problems (and generalizations thereof) based upon our earlier successful efforts on the constrained least squares problem [4].

REFERENCES:

[1] K.W. Heiner, M. Kupferschmid and J.G. Ecker, Maximizing Restitution for Erroneous Medical Payments when Auditing Samples from More than One Provider, INTERFACES 13 (1983) 12-17.

[2] I. Mifflin and R. Mifflin, A BASIC Program for Solving Univariate Constrained Minimization Problems, Dept. of Pure and Applied Mathematics, WSU, Pullman, 1983, under revision for IEEE MICRO.

[3] R. Mifflin, Semismooth and semiconvex functions in constrained optimization, SIAM Journal on Control and Optimization 15 (1977), 959-972.

[4] R. Mifflin, A stable method for solving certain constrained least squares problems, Mathematical Programming 6 (1979), 141-158

[5] R. Mifflin, Stationarity and Superlinear Convergence of an Algorithm for Univariate Locally Lipschitz Constrained Minimization, Mathematical Programming 28 (1984) 50-71.

[6] R. Mifflin, Better than Linear Convergence and Safeguarding in Nonsmooth Minimization, in P. Thoft-Christensen, ed., System Modelling and Optimization, Springer-Verlag, to appear.

[7] M.J.D. Powell, VMCWD:A Fortran subroutine for constrained optimization, DAMTP 1982/NA4, Cambridge, July 1982.

END

FILMED

10-84

DTIC